New Material Promises Higher Performance Military Aircraft Engines

Payoff

Use of gamma titanium aluminide materials in aircraft engines will lower engine weights (with increased thrust-to-weight ratios)and will enable design of smaller engine components.

Accomplishment

A Partnership for Research Excellence and Transition (PRET) initiated by the Air Force Office of Scientific Research in 1995, has led to the transfer of gamma titanium aluminide (TiAl) materials to industry for manufacturing future high-temperature (900°C) gas turbine engines. The PRET with three universities (Carnegie-Mellon, Ohio State, and Michigan) and six companies (Allied Signal, Allison Engine Company General Electric Aircraft Engines, Howmet Corporation, Precision Castparts Corporation and Rockwell International) is led by Profs. T. Pollock and P. Steif and focuses on the fundamental issues of the material’s microstructure, processing and design that are relevant to its transfer into production aircraft components. Carefully planned experiments performed under this PRET project enabled the development of valuable data used in the final GE low-pressure turbine design review.

Background

Among the intermetallic materials under study for possible application in aircraft engines, TiAl materials are among the most promising. Among its many positive properties (stiffness, high strength, high-temperature oxidation stability and creep resistance), the material is more than 50% lighter than the currently used nickel-based superalloys. However, one major, critical concern regarding the materials use in gas turbine components involves the materials observed low ductility — a reflection of its brittle behavior. This leads to cracks without warning, making the material’s use unreliable. One PRET task, led by Professor J. Beuth of Carnegie-Mellon University, achieved accomplishments which addressed the ductility issues. Research at Carnegie-Mellon, showed the TiAI material’s total failure strain was determined to be in the one to two percent range. Though limited in its plastic capability, it is sufficient to reduce material stress concentrations. This is important because it is the accumulation of local stress concentrations that lead to rapid material failure. Tests to determine the dependence of ductility on various geometric and material parameters — based on notched and unnotched specimens – show notch strengthening parameters allow the material to function with greater resistance. While a complete theory is being developed, the team's findings are already influencing the activities of industrial partners and contributing to the development of future aircraft engines.